How long is the charmed lifetime?

from Graham Shaw

By remarkable techniques akin to the systematic location of needles in haystacks, experimental physicists have made considerable progress towards determining the lifetimes of charmed particles. In so doing, they have confirmed yet another fundamental feature of the unified theory of weak and electromagentic interactions (see *Nature*, **282**, 131; 1979).

According to theory, the lightest charmed particles should decay by weak interactions, since charm itself is conserved by the more powerful strong and electromagnetic interactions. And these weak interactions should be the same as those responsible for familiar processes like muon decay, or nuclear beta decay, with precisely the same coupling constant. However, because the charmed quarks are so much heavier than the strange quarks to which they decay, the density of allowed final states available (the 'phase space') is much greater in charm decays than in, for example, muon decays, so that the predicted lifetimes are much shorter. How much shorter depends on the charmed quark mass, but with reasonable values, lifetimes τ in the range 10^{-12} to 10^{-14}s are obtained, compared to 2.10^{-6}s for the muon lifetime.

Turning to experiment, such short lifetimes $\tau \sim 10^{-13}$s present a serious challenge, since in a typical charm production experiment they imply decay lengths of a few hundred microns. This distance is of the same order as the bubble size in a typical bubble chamber, so that the resolution required is on the edge of what may be achieved with this technique. Very much better spatial resolution can be obtained by observing charmed particle production and decay in photographic emulsion stacks. In this case, the problem is not to resolve the details of a given event, but to find it. The events are relatively rare, and in general occur deep in the stack, so that it would take innumerable man years of effort to locate them in sufficient numbers to be interesting, A method is required to locate the needles in the haystack, without sifting every straw. This is provided in a series of so-called hybrid experiments by placing an array of electronic counters and/or a bubble chamber behind the stack (see *Nature* **279**, 287; 1979). These can be used to detect the particles produced together with the charmed particle, and the decay products of the said particle, when they emerge from the stack. They serve a triple purpose: to select out possible charmed particle events from more numerous backgrounds; to identify and measure the momenta of the emerging particles; and by tracing back the flight paths of the particle into the stack, to locate the small region in which the event occurred.

An example of an event located in this way is shown in the figure, with best fit lines drawn through the measured positions of grains in the emulsion (Adamovich *et al.*, *Phys. Letters* **89B**, 427; 1980). In this experiment, an 80 GeV tagged photon beam is incident from the left, and the event clearly indicates a neutral particle being produced at the first vertex, and decaying at the second. Information from the external counters indicates $\pi^+\pi^-\pi^-K^+$ as the most likely identification for the decay products 1d, 2d, 3d, 4d, and leads to a mass for the decaying particle of 1866 ± 8 MeV/c^2, coincident with the mass of a charmed $\bar{D}^0$ meson. On the basis of this and other detailed considerations, the authors conclude that the production and decay of a $\bar{D}^0$ meson has almost certainly been observed. The distance between the production and decay vertices is measured in the emulsion as 122.7 ± 2.2 μm, with a corresponding decay time of (2.26 ± 0.05) 10^{-14}s.

Similar events have also been seen in several other hybrid experiments (see Voydovic, *Proceedings of the International Symposium on Lepton and Photon Interactions at High Energies*, Fermilab, Batavia, in press). In particular, a group working at Fermilab with a neutrino beam, has reported as many as ten events in which the decaying charmed particle can be identified (Prentice, ibid.). These include two Λ_c baryon decays with a mean decay time of about 4.10^{-13}s, four $D^\pm$ or $F^\pm$ meson decays with a mean decay time just under 10^{-12}s, and four D^0 meson with an appreciably shorter mean decay time of about 7.10^{-14}s.

These experiments, and others like them (Voydovic, ibid.) clearly show that charmed lifetimes lie in the expected range, providing further striking evidence for the universal coupling of the weak interactions. They also begin to reveal more detailed features, like the relative shortness of the D^0 lifetime, which has aroused considerable theoretical interest (see Rosen, *Phys. Rev. Letters* **44**, 4; 1980; Bander *et al.*, ibid. **44**, 7; 1980). Hopefully, this is only the beginning. ☐

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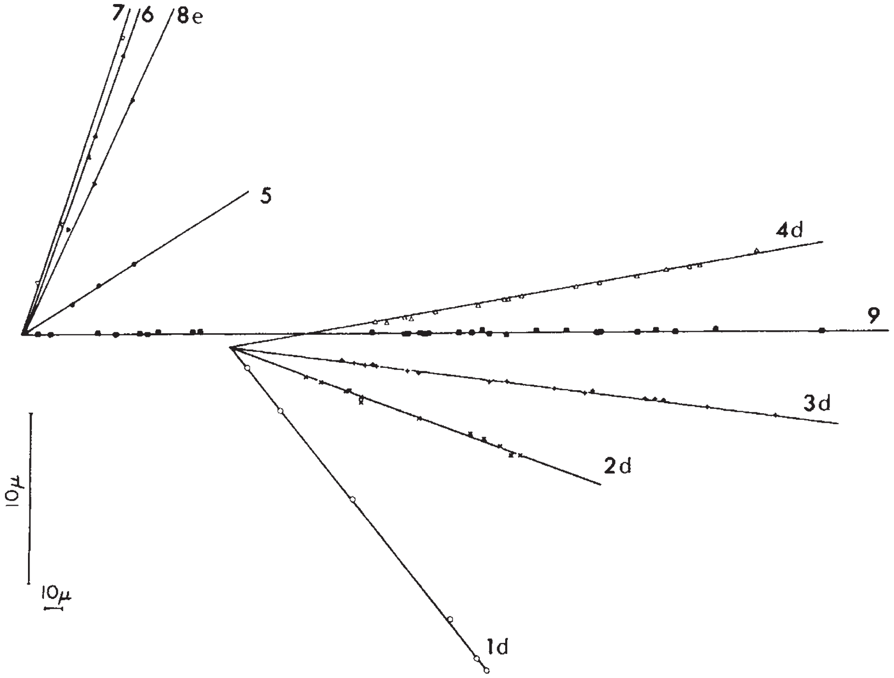

Dendrochronology

from Sara Champion

Current European research in dendrochronology is extending the possibility of accurate dating back into the 1st millennium B.C., and in doing so is confirming observations which could previously only have been made by the conventional method of artefact cross-dating.

When Bruno Huber, the founder of European dendrochronology, died in 1969, his master chronology for Central European oak stretched back from the present for over 1000 years (Huber, *Handbuch der Mikroskopie in der Technik* **5**, 171; 1970). He had shown that the considerable variations in the ring widths of coniferous trees in North America caused by extreme temperatures, which allowed the crossmatching of skeleton plots, did not occur in the tree population in the more temperate European climate, rendering this method of crossmatching inapplicable. Concentrating on oak, the

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